Proceedings of the UGC Sponsored National Seminar

Sustainable Resource Management

Tools and Techniques

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ST. TERESA'S COLLEGE
(AUTONOMOUS)
ESTD 1925

First Edition : 2014

Proceeding of the National Seminar on
Sustainable Resource Management - Tools and Techniques

ISBN : 978-81-7255-066-9

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Published by
Department of Home Science
St. Teresa's College, Ernakulam - 682011

Distributors
Sooryagatha (Publishers)
P.O. Box 3517, KEWF Bldg.
Ernakulam College, Kochi - 682035

Printed by
Touchstone Print Products
Kochi - 682035

EVALUATING THE MULTIPRONGED SERVICES OF MANGROVES IN THE DYNAMIC COASTAL ECOSYSTEMS

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INTRODUCTION

Coastal areas are commonly defined as the interface or transition areas between land and sea. These areas are diverse in function and form, dynamic and do not lend themselves well to definition by strict spatial boundaries. Favourable biophysical and climatic conditions, together with the ease of communication and navigation frequently offered by coastal sites, have encouraged human settlement in coastal zones since prehistoric times. The coastal zone is an area of convergence of activities in urban centres, such as shipping in major ports, and wastes generated from domestic sources and by major industrial facilities. Thus, traditional resource-based activities, such as coastal fisheries, aquaculture, forestry and agriculture, are found side by side with activities such as industry, shipping and tourism. Coastal areas are also important ecologically, as they provide a number of environmental goods and services. The peculiar characteristic of coastal environments is their dynamic nature which results from the transfer of matter, energy and living organisms between land and sea systems, under the influence of primary driving forces that include short-term weather, long-term climate, secular changes in sea level and tides.

India's Coastal Zones

India has a long coastline of about 7500 km including its island territories, which consists of a variety of coastal habitats (areas) such as estuaries, mangroves, coral reefs, etc. These coastal areas with unique characteristics are considered as "critical habitats" as they are unique, fragile and exhibit high biodiversity, supporting several coastal and marine plants and animals. By virtue of these habitats located in coastal areas, their high productivity and the services they

offer, they are subjected to ecological pressure due to natural processes and human interventions. The combined pressure of natural processes and human activities cause changes in these critical habitats leading to deterioration and/or loss of these areas over the years. The Agenda 21 adopted in United Nations Conference on Environment and Development (UNCED-1992) emphasises the need for protection of coastal and marine environment.

Mangroves and its significance

Of the very many unique features of the coastal ecosystem, the mangroves play a significant role. Mangroves are salt-tolerant plants of tropical and subtropical intertidal regions of the world. The specific regions where these plants occur are termed as 'mangrove ecosystem'. These are highly productive but extremely sensitive and fragile. Besides mangroves, the ecosystem also harbours other plant and animal species. The distribution of mangrove ecosystem on Indian coastlines indicates that the Sundarban mangroves occupy very large area followed by Andaman-Nicobar Islands and Gulf of Kachh in Gujarat. Rest of the mangrove ecosystems is comparatively smaller. Over 1600 plant and 3700 animal species have been identified from these areas.

Mangroves act as a barrier against cyclonic storms, protecting the land behind. They also act as a buffer against floods, preventing soil erosion. Mangroves trap fine sediments that are carried into the coastal zone by floodwaters, and there is a significant net export of nutrients from the mangroves into the coastal zone, which acts as a source of enrichment for the marine environment. Mangroves prevent inorganic nutrients being sunk in the sea through swift flowing terrestrial runoff and synthesise organic matter absorbing the inorganic nutrients. Hence various inorganic nutrients from the terrestrial runoff are recycled within the mangrove environment. They are breeding, feeding and nursery grounds for many estuarine and marine organisms. Hence, these areas are used for captive and culture fisheries. The ecosystem has a very large unexplored potential for natural products useful for medicinal purposes and also for salt production, apiculture, fuel and fodder, etc.

Leaf litter production by mangrove plants contributes largely to the organic matter available to the ecosystem. Thus the terrestrial and aquatic components of mangrove ecosystem contribute to each other enabling high productivity of the ecosystem. Due to their

productive nature, they serve as nurseries for prawns, crabs, lobsters, and various fishes such as mullet. Mangroves also shelter a number of endangered animals such as crocodile, turtle and pelican. Mangroves offer a variety of commercial utilities in the form of wood for timber and fuel, fodder for cattle and with substances of commercial value such as lignin, tannin, etc. It is scenic and an excellent place for pleasure boating and thus contributes to the tourism industry.

Exploitation and Policy interventions

Mangroves have been exploited by mankind for various uses, such as fishing, aquaculture and salt production, felling for timber and fuel wood, for substances of commercial importance, tourism, etc. These human interventions along with the natural forces such as waves, currents, tides, storms, rainfall, fresh water runoff, etc. have caused changes in mangrove areas world over.

World-wide mangroves are disappearing at an alarming rate. In some developing countries about 80% of mangroves were lost in the last 20 years. The largest mangrove area occur in Indonesia (30%), Brazil (10%), Australia (8%) and Nigeria (7%), but in India only 3% of mangroves occur (Mastaller, 1996).

Mangroves have been exploited for thousands of years in the all of India, except for the areas in the Andaman and Nicobar islands, where they are nearly undisturbed. Most estuarine mangrove areas have human communities close by, while the Sundarbans mangroves have a resident population of some two million people. Pollution from urban and agricultural runoff is an increasing threat. On the east coast, a number of mangrove areas are managed for timber with detailed Forest Working Plans and felling cycles varying from 20 to 100 years. Over-exploitation threatens many areas, including the Gulf of Kutch and the Sundarbans. A National Mangrove Committee was established in 1979, now superseded by a National Committee on Wetlands, Mangroves and Coral Reefs, as an advisory body to the government.

The year 2011 saw the issue of Coastal Regulation Zone (CRZ) under Environment (Protection) Act 1986 by the Ministry of Environment and Forest. CRZ 2011 notification aims to ensure livelihood security to the fishing communities and other local communities living in the coastal areas; conserve and protect coastal stretches and; To promote development in a sustainable manner based on scientific principles, taking into account the dangers of natural hazards in the coastal areas and sea level rise due to global warming.

CRZ area is classified as CRZ-I (ecological sensitive), CRZ-II (built-up area), CRZ-III (Rural area) and CRZ-IV (water areas up to the territorial waters and the tidal influenced water bodies). The mangroves which are hyper sensitive and unique in nature fall under CRZ I. Even with the issue of such regulations the value of Mangroves are undermined.

Economic Evaluation of Ecosystem services of Mangroves:

This study attempts at projecting the ecosystem value by employing economic tools. Since the mangroves offer multiple ecosystem services, it is impossible to evaluate all the services with one single tool. Thus identifying the appropriate tool for individual services is necessary.The major ecosystem services include Disaster risk reduction, carbon sequestration, biodiversity conservation, livelihood sustenance and food security, and recreation.

Disaster Risk Reduction

In order to evaluate the Disaster risk reduction service of mangroves such as flood control, storm buffering and sediment retentionreplacement coast method (RCM) is used. The replacement cost method uses the cost of replacing an ecosystem or its services as an estimate of the value of the ecosystem or its services. Studies show that where mangroves are intact they work as an effective buffer against tsunamis (UNEPWCMC 2006) and that 30 trees per $100m^2$ in a 100m wide belt may reduce tsunami flow rate by as much as 90% (EjF, 2006).To get a clearer picture of the study, a Model village with mangrove ecosystem is taken into consideration. Say, the village has a population of 300 households, and a mangrove cover of 25 ha.

A	Number of houses	300
B	Average house price(US$)	8200
C	Value houses (US$) (A*B)	24.6
D	Likelihood of any severe weather event in coastline per year	10%
E	Value shoreline protection (C*D in US$)	246 lakhs
F	Mangroves in model village	25 ha
G	Value shoreline protection(US$ / ha / year)	**9.84 lakhs USD**

Carbon Sequestration

Due to their high biomass density and productivity mangroves play a significant role in carbon sequestration. According to Giri et al.(2010) mangroves, including associated soil, could sequester approximately 22.8 million metric tons of carbon each year. Covering only 0.1 per cent of the earth's continental surface, the forest would account for 11 per cent of the total input of terrestrial carbon into the ocean and 10 per cent of the terrestrial dissolved organic carbon exported to the ocean. To evaluate this service, replacement cost method is employed.

Biodiversity

Mangroves in their undisturbed state are regarded as a refuge for rich biodiversity. Biodiversity value combines direct, indirect and non-use valueand is a valuation of human preference rather than actual value (UNEP/GPA, 2003).This services can be evaluated by benefit transfer method (BTM). The procedure estimates the value of an ecosystem service by transferring an existing valuation estimate from a similar ecosystem (TEEB, 2010). The following equation is used to evaluate the biodiversity value of mangroves.

Value y = Value x (PPP GNPy /PPP GNPx)E

Where

PPP GNP =Purchasing power parity GNP per capita

E = Elasticity of values with respect to real income (UNEP/GPA (2003) assumed E=1.00)

E = 1.00 implies a 1 per cent change in WTP relative to a 1 per cent change in real income.

Tourism/ Recreation

Tourism has always been a major source of income for any coastal population and since mangroves provide rich biodiversity and an impressive landscape, tourism could represent a reasonable part of the economic value of mangroves. The study recommends applying the Travel Costs Method(TCM) where primary data is available. The basic premise of the travel cost method is that the time and travel cost expenses that people incur to visit a site represent the "price" of access to the site. Thus, peoples' willingness to pay to visit the site can be estimated based on the number of trips that they make at different travel costs.

Step one is to define a set of zones surrounding the site, followed by collection of information on the number of visitors from each zone, and the number of visits made in the last year. The next step is to calculate the visitation rates per 1000 population in each zone and then calculate the average round-trip travel distance and travel time to the site for each zone.Consequently using regression analysis, derive the equation that relates visits per capita to travel costs, with the aid of demand function for visits to the site, using the results of the regression analysis. Finally estimate the total economic benefit of the site to visitors by calculating the consumer surplus, or the area under the demand curve.

Food Security & Livelihood Sustenance:

The most valuable direct use of mangroves is as a breeding and nursery habitat for juvenile fish. To calculate the compounded annual growth rate (CAGR) for the marine fisheries industry the following formula is applied:

Where:

$CAGR\ (t_0,t_n) = [V(t_n)/V(t_0)]^{(1/t_n - t_0)} - 1$

CAGR = Compounded annual growth rate

t_0= time 0

t_n= time n

$V\ (t_0)$ = Fish catch in time 0

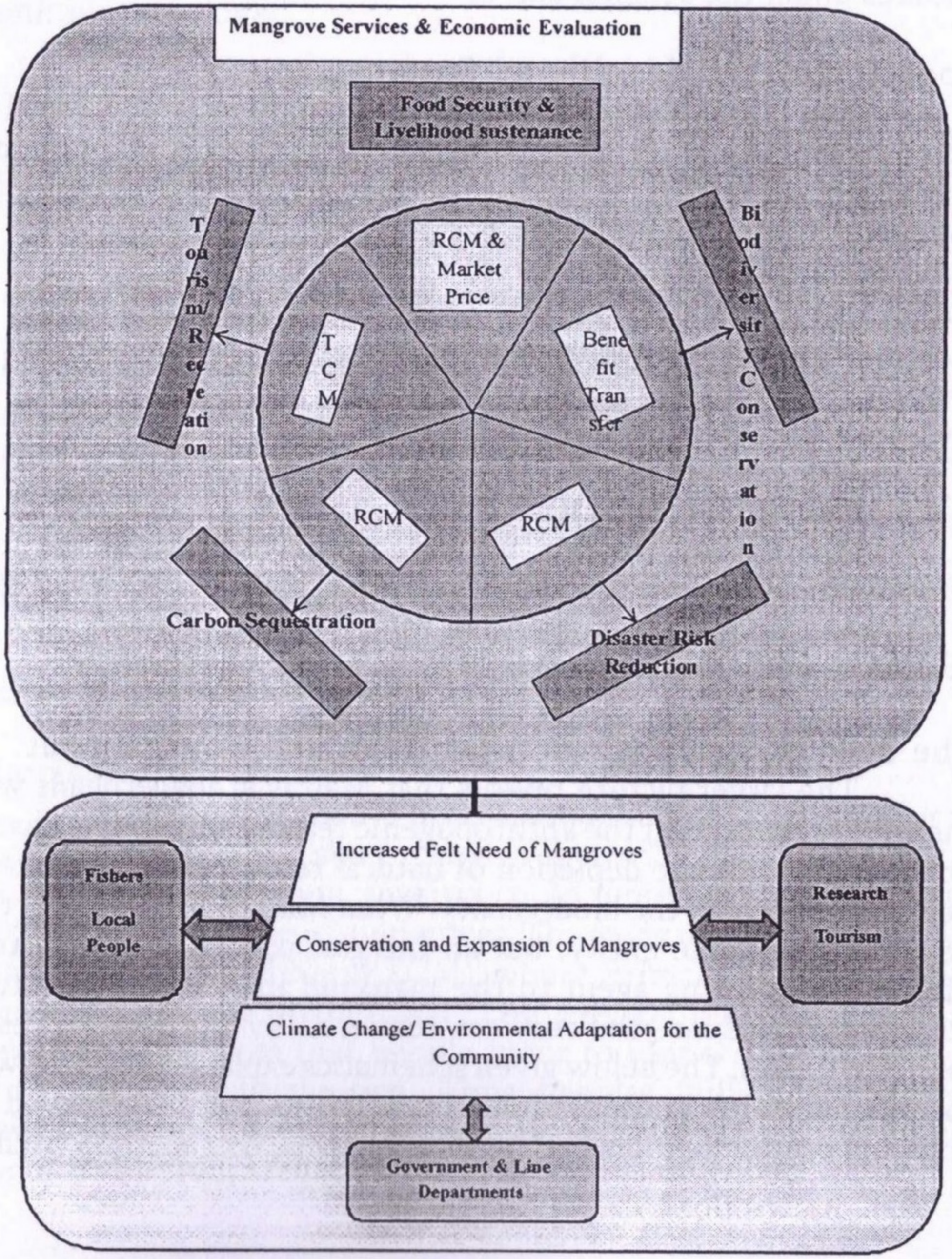
$V\ (t_n)$ = Fish catch in time n

Apart from fisheries, which also serves as a tool for food security, the other livelihood opportunities that the mangroves offer is firewood collection, apiculture and aquaculture which can be evaluated using Replacement cost method and market price.

The need of symbiosis between Man and Environment

The larger picture reveals that Man is at loggerheads with the environment, be it the anthropogenic reasons for climate change or the indiscriminate depletion of natural resources, or the care-a-heck attitude about the biodiversity. What Man fails to realise is that he is not a separate entity, but an integral part of the ecosystem. Money being luring agent to the mankind in general, this study attempts to evaluate the services rendered by the Mangroves in monetary terms. The below given schematics explains the phase wise manner in which conservation of mangroves can be achieved by applying economic tools such as Replacement cost method (RCM),

Travel cost method (TCM), Benefit transfer method (BTM), Market price to various services of mangroves. By doing so the value of the mangroves is quantified, and its precedence is understood by the community. This eventually leads to a situation where conservation and probably expansion of mangroves can happen, which is mutually beneficial to the environment and the stakeholders, which include fishers, local people, researchers, tourism and the government. The added benefit includes in developing a resilient and a self-sustaining community.



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